LOW IMPACT DEVELOPMENT

NEW SMART TECHNOLOGY FOR CLEAN WATER

"Definition / Issues / Roadblocks / Next Steps"

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I. Introduction

Low Impact Development (LID) provides new economically and environmentally sustainable tools for local and state officials, the private sector and others to better address nonpoint pollution wet weather flow regulatory challenges for the protection of our receiving waters. LID has initiated new dialogue, opened up new areas of research, provided new management tools and has caused us to question many of our past urban nonpoint pollution control approaches. LID represents the most advanced stormwater management technology and has evolved from the lessons learned over the past 30 years here in the United States and around the world. Through LID's new advance technological tools it is possible to have better environmental protection for significantly less cost.

However, despite the demonstrated environmental and economic advantages of LID over today's conventional approaches, there remain numerous barriers to its widespread acceptance and utilization. These barriers are well understood and typical for an emerging technology. They include issues related political agendas, institutional structure and philosophy, lack of professional education and training, competing and vested interests in maintaining the status-quo, regulatory conflicts and inflexibility, lack of funding for research and development and professional / personal beliefs, knowledge and preferences. The following is a summary of LID's basic principles / practices and some of the issues and roadblocks to adopting LID as a cost effective mainstay of our urban stormwater technology.

II. What is Low Impact Development?

LID is a comprehensive source control technology. Prince George's County, Maryland first pioneered LID in 1997 to help address the growing economic and environmental limitations of conventional stormwater management practices. As LID was developed by a local government, it is sensitive to addressing local government's unique environmental and regulatory needs in the most economical manner possible by reducing costs associated with stormwater infrastructure design, construction, maintenance and enforcement. LID also provides for local government's need for economic vitality through reasonable and continued growth and

redevelopment. LID allows for greater development potential with less environmental impacts through the use of smarter designs and advanced technologies to achieve a better balance between conservation, growth, ecosystem protection and public health / quality of life.

LID is simple and effective. Instead of the large investments in complex and costly centralized conveyance and treatment infrastructure, LID allows for the integration of treatment and management measures into urban site features. LID encourages the multifunctional cost-effective use of the urban green space, buildings, landscaping, parking lots, roadways, sidewalks, and various other techniques to detain, filter, treat and reduce runoff. LID is completely different from conventional management strategies. Conventional practices use highly efficient drainage systems to get water off a site as quickly as possible to a *centralized treatment device* (i.e., stormwater pond). LID uses many *decentralized micro-scale at the source control techniques* to manage runoff. This involves strategic placement of distributed lot-level controls that can be "customized" to more closely mimic a watershed's hydrology and water quality regime. One of the primary goals of LID design for new development (greenfields) is to reduce runoff volume through infiltration, recharge, evaporation and finding beneficial uses for rainwater rather than disposing of it as a waste product into storm sewers. The result is a landscape that is functionally equivalent to predevelopment hydrologic conditions that generates less surface runoff, less pollution, less erosion and damage to lakes, streams, and coastal waters.

LID is economical. It costs less than conventional stormwater management systems to construct and maintain, in part, because of fewer pipes, few conveyance structures and less impervious surface. But the benefits do not stop there. Space one dedicated to stormwater ponds can now be used for additional development to increase lot yields or provide for more conservation. The greater use of on lot multipurpose landscaping / vegetation also offers human "quality of life" opportunities by greening neighborhoods thus contributing to livability, value, sense of place, and aesthetics. Other benefits include enhanced property values and re-development potential, greater marketability, improved wildlife habitat, thermal pollution reduction, energy savings, smog reduction, enhanced wetlands protection, and decreased flooding. LID is a multi-dimensional approach with multiple benefits.

LID is flexible. It offers a wide variety of structural and nonstructural techniques to provide for both runoff quality and quantity benefits. LID works in highly urbanized constrained areas and environmentally sensitive areas for urban infill or retrofit projects. In a combined sewer system, LID can reduce both the number and the volume of sewer overflows. Opportunities to apply LID principles and practices are infinite as any feature of the urban landscape can be modified to control runoff (e.g., buildings, roads, walkways, yards, open space) or reduce the introduction of pollution.

LID is a balanced approached. LID is an advanced ecologically based land development technology that seeks to better integrate the built environment with the natural environment. LID's principles and practices allow the developed site to maintain its predevelopment watershed and ecological functions (hydrology, water quality and habitat structure). LID tools include five basic techniques: 1) encourages conservation measures (wetlands, streams, woodlands and buffers); 2) promotes impact minimization techniques (impervious surface reduction and disconnection); 3) provides for strategic runoff timing (slowing water down to allow infiltration and evaporation); 4) uses an array of integrated management practices (rain gardens and

amended soils); and 5) advocates pollution prevention measures to reduce the introduction of pollutants to the environment.

The more LID techniques used the closer one can get to restoring the natural hydrologic and water quality regime of a watershed. LID now gives us the tools to design the built environment to remain a functioning part of and ecosystem instead of apart from it. The effectiveness of LID technologies is only limited by the knowledge and skills of the site engineers / designers. There is no one technique for LID. Its power lies in the cumulative benefits of all its techniques.

III. Why LID Should Matter to Local Officials?

LID has numerous benefits and advantages over traditional / conventional approaches. In short, it is a more environmentally sound technology and a more economically sustainable approach to addressing the adverse impacts of urbanization. By addressing runoff close to the source though intelligent site design, LID can enhance the local environment and protect public health while saving developers and local governments money. LID promotes fiscal health, protects environmental assets and builds community livability. Other benefits include:

1. LID addresses the tough new nonpoint source / stormwater management regulatory challenges faced by states and localities in the least onerous and most economically sustainable manner.

2. LID provides superior protection of source waters (surface and ground water reservoirs) from the impacts of nonpoint runoff and ground water contamination associated with urbanization.

3. Through more effective and flexible technologies, local governments can better balance their unique conservation, growth and economic development objectives.

4. LID reduces stormwater conveyance and management infrastructure and their associated construction, maintenance and enforcement costs.

5. Since LID uses multiple systems it is more effective in addressing unique water pollution and aquatic habitat degradation than conventional one-dimensional best management practices (BMP's).

6. LID technologies are universally applicable for all greenfields, brownfields and urban redevelopment applications in any climatic or geological region.

7. LID has added benefits beyond clean water, including increased quality of life, fiscal health, reduced air pollution, water conservation, better habitat protection and increased property values.

8. LID provides a better balance between growth necessary for economic vitality than the popularized growth management and conservation oriented approaches.

IV. How are Federal, State and Local Communities Using LID?

There are a growing number of local, state and federal projects / programs that are using and demonstrating LID technologies. Listed below are just a few examples of LID initiatives.

1. The U.S. EPA's Office of Research and Development and Office of Water have provided some funding to help advance the development of new models to analyze LID's multiple scale systems and provided limited grants for a few outreach and demonstration projects.

2. U.S. EPA and Prince George's County held the first national LID roundtable. Bringing together forty-five national experts to discuss their latest research and the issues / roadblocks faced in gaining wide spread acceptance of emerging more effective innovative technology.

3. Washington D.C. Government and their water and sewer authority with the encouragement of EPA Region III is using LID as part of the city's long-term combined sewer overflow control plan. LID's small-scale space-saving source control techniques make it a powerful technology to retrofit existing urban areas.

4. The Chesapeake Bay Program's Executive Council (comprised of the governor's of Maryland, Virginia, Pennsylvania and the Mayor of District of Columbia) have issued a new stormwater management directive to their respective jurisdictions to include LID in their stormwater programs for greenfield and urban retrofit development.

5. Voluntary watershed restoration associations such as the "Chagrin River Partnership" in Ohio and the "Friends of the Rappahannock River" in Virginia are aggressively conducting outreach and education programs for their members to promote LID's low cost smart technology. Local government members are particularly excited about LID's economic benefits that reduce infrastructure maintenance burdens and maintain development potential.

6. There are a number of demonstration projects such as the Navy Yard in Washington D.C. and the Jordan Cover subdivision in Connecticut that have showcased various LID technologies for urban retrofit and greenfields development.

7. The Puget Sound Water Quality Action Team's (part of the National Estuary Program) conducted the first national conference on LID in Seattle, Washington in 2001. The conference provided the first opportunity to for experts and pioneers in source control technologies to have a venue to discuss and display innovative control approaches

8. In addition to the above United States examples there are many other examples overseas in both Europe (Germany and France) and the Pacific Rim nations (Australia, New Zealand, Taiwan and Japan) where LID or onsite distributed source control stormwater management technology has been practice for some time with great success.

V. Barriers to Using LID Tools for Water Protection

Despite the successes of LID, the majority of jurisdictions across the Nation do not know about LID or remain comfortable with business as usual unconvinced that change is not necessary or would not be beneficial. LID challenges current conventional thinking and approaches to stormwater management. Therefore, it is expected that those vested in traditional approaches would be skeptical, doubtful, suspicious or misinformed about what LID is and its possibilities. There are many questions surrounding LID that have been expressed by consultants and practitioners. However, it is interesting to note that since the release of the first LID design manual in 1997, no one has ever challenged the technical and scientific merits of LID's decentralized micro-scale source control strategy. To challenge LID on a technical basis would require challenging our current basic scientific understanding and engineering principles of hydrology, hydraulics, ecology, biology, etc.

The criticism of LID has only been based on speculation and misinformation about LID's practical application and long-term maintainability. All of the criticism has come from those not familiar with or experience with the use of LID technology. Those not wishing to take any risks have used the speculative issues surrounding LID as a way to resist change and maintain the status quo. It is not easy (for many reasons) for the professionals in the field to make the necessary fundamental paradigm shifts from conventional approaches to LID approaches.

The most common issues about LID are discussed below. All of these issues can be easily resolved through increased efforts in education and awareness of the benefits and application of LID technologies.

Issue 1. There is nothing new about LID, we've done it for years.

Many have been mislead or are ignorant of the current definition and objectives of LID. The term LID is a generic one much like sustainable development. A literal interpretation of low impact development (to lesson development impacts) could also be used to describe current technology. Advocates of more traditional approaches that heavily favor conservation and use of less effective and costly BMP's are quick to use the new hot term of LID to describe their old approaches. Many within the established professional organizations and consulting services have a vested economic interest in continuing to market conventional technologies and maintaining the status quo. Few in the industry of stormwater management (professional engineers, practitioners, planners, etc.) want to admit that there is a growing body of evidence exposing the economic and environmental limitations of current technology. After all, for the last twenty years we have been making claims that we use the "best management practices". It is very hard to admit that perhaps current technology may not be the best.

Many detractors lump LID into the popularized impact minimization strategies of better site design, conservation design or growth management. However, LID goes far beyond the goal of impact mitigation of these conventional approaches by providing many more technological tools to plan and engineer a site to maintain or restore a watershed's hydrologic and ecological functions. LID requires strategic and customized use of conservation measures, multifunctional small-scale controls, and pollution prevention to address site-specific stormwater pollutant loads, timing, flow rate, and volume needs. This is not the same as a broad-brushed set of generic site

design or conservation tools that merely reduce impacts or sacrifice the environmental quality of urban watersheds for greater protect of conservation areas.

Simply put, LID is a new approach using decentralized integrated source control practices making more cost effective and efficient use of a site to maintain the watershed hydrology and water quality. The conventional approach uses a separate and centralized approach that results in the creation of a large stormwater infrastructure to convey and treatment runoff that also competes with valuable space.

Issue 2. Where is the scientific data that LID works better than ponds?

LID technology is a very recent development. There is no great body of research and monitoring data on the long-term application of the combined affects of the entire suite of LID principles and practices. However, LID is based on sound scientific and engineering principles, knowledge and experience. Every technique used in LID has been used in one way or another for urban stormwater control or used in another related field of water / wastewater treatment. This question is symptomatic of the specialization, compartmentalization, isolation and parochialism that stormwater consultants and practitioners often exhibit. LID is based on what we have learned over the years about stormwater management and the application of technology transferred from other fields of engineering and science such as sanitary engineering, agriculture, forestry, soil science, phytoremediation, bioremediation and ecology. As an example, the 50-year history of the successful land application and treatment of wastewater effluent clearly demonstrates the effectiveness of the plant / soil complex to assimilate pollutants for either wastewater or urban runoff. With the use of innovative thinking and a little common sense, LID simply combines a variety of current practices and adapts other technologies to treatment urban runoff.

There is an existing and growing body of research and data on the performance of a variety of LID techniques such as bioswales, bioretention, grass filter strips conducted by universities (Maryland, Virginia and Washington State), Federal Highway Administration, EPA and others. When you the look at the entire body of existing and related scientific data and engineering / environmental technologies, you begin to see the advantages and benefits of LID's multiple systems (treatment train) approach. Just looking at the monitoring data on bioretention (rain gardens) alone shows it to be far more effective than any other stormwater BMP or pond. The data is all there for those who want to look for it and are open to the transfer of science and technology from other fields of science and engineering.

In 2000 Prince George's County began monitoring a paired watershed (conventional design versus a LID prototype design) for stormwater runoff flow and found the LID site generates 2/3 less flow than the conventional site for small storm events. When you add the flow and frequency reductions that can be achieved with LID, you get the added benefits of reducing total annual pollutant loads by reducing runoff volumes and erosion potential.

We can't afford to wait 20 years to generate the data to absolutely prove that LID works to the skeptics resisting change. For those most comfortable with the status quo, there will never be enough evidence to justify change. For example, we have been collecting data on conventional BMP's for the last twenty years and there are still remains questions about its

efficacy. Despite the fact that many studies show that current technology does not meet our ecological protection goals, this has not resulted in a change in institutional thinking or any significant movement to improve the technology. This in part a result of the fact that current technology has been codified into state and local regulations and is reinforced by institutional thinking of administrators, universities and professional organizations. Traditionalist feel threatened and want to block the development of LID's because of its potential to totally replace current approaches. However, the goal of those advocating LID is not to replace traditional approaches but to complement and expand our toolbox of solutions to better meet our most difficult ecological challenges.

Issue 3. LID is unreliable since the long-term maintenance of on-site privately owned practices cannot be guaranteed.

What's to stop property owners from filling in the rain gardens or cutting down trees? This concern demonstrates a fundamental lack of understanding of the comprehensive nature and wide array of practices used in LID. Many try to simplify LID by characterizing it as only relying on rain gardens and rain barrels that will not be maintained by the property owner. They fail to recognize or don't want to understand that LID is a comprehensive multiple systems approach using dozens of techniques that retain, detain, infiltrate, recharge, filter, use, modify runoff timing and prevent pollution in order to maintain and restore hydrology and water quality. LID multiple systems approach has built-in redundancy that greatly reduces the possibility of failure. Many LID techniques have nothing to do with nor can they be significantly influenced by the behavior of the property owner. These include basic subdivision and infrastructure designs features such as reducing the use of pipes, ponds, curbs, gutters, saving recharge areas, saving streams / drainage courses, infiltration swales, saving buffers, reducing impervious surfaces, disconnection, open space conservation, grading strategies, saving streams/ wetlands / buffers, disperse drainage and using open drainage systems. LID's long-term success has much more to do with the knowledge, skills, intelligence and creativity of the site designer (planners, engineers, architects, and environmental scientists) to design an ecologically sound site than what the property owner does or doesn't do.

Furthermore, the LID allows for additional storage volume as a margin of safety to account for some losses over time (although it is expected that LID will work better over time). If one wants to raise their level of comfort about maintenance of on-site landscape features, they can be placed easements with maintenance agreements. Experience has shown (not speculation) that using smart designs will reduce maintenance burdens for property owners and local governments.

LID site source controls encourage property owners to be responsible for the impacts associated with their property. This ensures and promotes active public engagement in protecting our receiving waters by the simple act of maintaining their properties. The key factor in the success of LID is to ensure that the landscape practices (such as rain gardens) are attractive and perceived by the property owner as adding value to the property. If we are successful in designing attractive LID practices that are viewed as assets, the primary motivation for long-term maintenance is economic. Property owners are much more likely to be motivated to maintain LID landscape practice to protect their vested economic interest in their property than out of a

sense of environmental stewardship. Also, LID techniques are simple, needing no special equipment and are inexpensive to maintain.

Issue 4. LID is more expensive to construct because it takes more time to get approvals for innovative techniques.

This can be true depending on the receptiveness of local government officials to innovative practices. If they are not receptive, reviewers will either not allow modifications or require extensive studies to show equivalency to current codes. Longer review times (if in the order of months) can increase the loan carry costs for a developer. Another cost increase is associated with design. Since LID is new, inexperienced consultants usually take much longer to design and will charge more for their services. This can also be true for construction costs. Inexperienced contractors will charge more for new techniques. There are cost increases associated with the increase use of on site landscaping material. However, despite these additional costs (over conventional approaches) experience has shown that LID still saves money through reduced infrastructure and site preparation work.

If a developer uses the entire suite of LID techniques it cost less for sediment control, clearing, grading, roadways, curbs, gutters, sidewalks, inlets, pipes and ponds. The developer can recover more developable space since there is no need to waste space for a stormwater pond. Generally, greenfields single-family residential development cost savings are typically four to five thousand dollars per unit or a 30% reduction in overall infrastructure costs. The reduced infrastructure construction eventually translates into reduced future costs for infrastructure maintenance. The infrastructure reduction savings far out weight any of the cost increases due to LID techniques.

Increased time to review is not an indictment of LID but of the institutions, individuals and bureaucracies that remain inflexible, unwilling to change or ignorant of the need and benefits to change.

Issue 5) LID conflicts with state and local land use laws.

In fact, just the opposite is true. This critic results from the lack of understanding that LID relies more heavily on smarter and advanced technologies than it does on conservation and growth management. LID is a technology for the built environment. Although LID promotes conservation as the first step for greenfields development, it remains the purview of the local jurisdiction to define the green infrastructure and buildable space based on their local objectives and within their regulatory requirements. LID is silent on the issue of growth management, architectural style or in promoting livable communities such as new urbanism. Once the local government defines their vision of the type of community /style they desire and the building envelope, LID provides technological tools for better protection of receiving waters. LID can be used for any type built environment.

However, the popularized conservation design, smart growth and better site design approaches (that generally promotes new urbanism) almost always conflicts with local land use laws as they require rezoning, clustering, changing lot sizes / yields or place limits on lot densities. Detractors of LID (or those resisting change) try to associate LID with these current

land use control orientated approaches. LID was developed by a local government in order to preserve a local government's right to determine zoning and land use. LID focuses more on modifying building codes and design standards (roadways, site grading, water uses and building criteria) to achieve better environmental protection. LID requires revisions or waivers to some building codes not zoning codes. LID provides a balance between conservation and technology to optimize both environmental protection and economic needs.

IV. Institutional Roadblocks to LID

Successful integration of LID's lot level management strategies into existing stormwater programs requires a major paradigm shift away from centralized controls to one of decentralized controls. In order for such a shift to occur elected officials, program administrators, civil engineers, urban planners, environmental scientist, technicians, plan reviewers, inspectors, contractors and maintenance personnel must be willing / motivated to change the way they do business and be educated on the new technologies and approaches. Below is a list of roadblocks to change that must be addressed to make change happen.

1. Leadership

Chang will not occur or be successful without strong leadership or an agent for change. Leadership can come from any sector including federal, state, and local governments, political leaders, environmental groups, businesses, institutions, and stakeholders. Generally, there is one person or a group of dedicated individuals that oversee and ensure that change occurs throughout the entire institutional structure. Change will not occur without intervention. In fact, bureaucracies, institutions, regulations, protocols, standards, convention and compartmentalization of disciplines generally work to maintain the status quo not to encourage change or innovation. Change is not easy and will not occur without leadership by example and a strong advocacy by a champion. It takes time, dedication, and perseverance by the agent(s) of change to ensure changes occurs.

2. Motivation

Change will not occur unless there is a motivation or reason to change. The best motivations for change include regulatory compliance, economic incentives, protection of a valued living or water resource, or a perceived problem that must be addressed by developing new goals, objectives and solutions. Under the municipal stormwater NPDES program the regulatory motivation is in place to encourage the use of stormwater management throughout the nation. LID can offer a more economical approach to achieving the regulatory objectives. Additionally, in many parts of the Country (Chesapeake Bay / Puget Sound) change is being driven by the need to protect endangered species and to protect economically important fisheries.

3. Inflexible Regulations

Federal, State and local enabling legislation and new regulatory standards must be in place to allow for the use of LID principles and practices. Existing standards and criteria

that discourage change and innovation need to be made more flexible to allow LID approaches. Current standards have evolved to meet past problems and objectives. If we are to meet the emerging complex and difficult problems of protecting receiving and ecological integrity from urbanization our regulations must be flexible enough to allow for innovation to change.

4. Perceived Competition with Growth Management Objectives

Because LID is a customized approach that can be used for any land use type or receiving water goal, it allows communities flexibility in providing environmental protection in exiting highly developed or new growth areas. In many urban areas growth may be difficult due to the proximity to sensitive environmental areas or exceeding a TMDL. LID provides the ability to develop a "customized" protection program that allows both growth and better environmental protection. However many advocates of growth management and conservation programs see LID's technological solutions as promoting urban sprawl and supporting continuation of consumptive development patterns. LID technology can allow higher density urbanization with less environmental impacts. LID provides solutions to protecting urban streams in growth areas. LID is a technology approach not a land use growth management approach for protection. Growth management programs require strong political commitments to hold the line on growth and reduce environmental impacts. What we do know is that growth management alone will not meet all of our water resources protection goals and that technology must play an important role in protecting and restoring our urban streams.

5. Education, Knowledge and Experience

Change will not occur unless professionals are aware that there are other viable options available. Unfortunately, neither federal nor state agencies have dedicate enough resources towards effective educate the of the nation's consultants and practitioners about other perhaps more effective technologies. Compounding the lack of awareness is the lack of technical expertise and experience to design and review new innovative technologies. A significant education program is need for all professionals in the field to better understand how to appropriately use LID technologies with cross-disciplinary training programs among water quality officials.

6. Ineffective Methods of Information Dissemination

Federal and state agencies have for the last several years spent tremendous resources on technical outreach. However, these efforts have for the most part focused on conventional approaches. For example, EPA is reluctant to place a high priority on emerging technologies (in their minds unproven techniques) for fear of failure. They have taken a very conservative approach to change, so much so, that even in the face of studies and research that either show problems with current technology or benefits of new approaches it has had little affect on how and what technical information they promote. Furthermore, the venues for disseminating information are very limited and generally not very effective. EPA has focused tremendous resources on supporting a few nonprofit groups to act as national clearinghouses to disseminate information on conventional

approaches. As these groups impart their own politics, philosophy, priorities and agendas (what they chose to or not to promote) they have severely limited dissemination of information and discussion / debate on alternative approaches. This has resulted in the nationalization of uniform thinking and promotion of conventional technologies. A national uniform standardized *"one-size fits all"* approach to urban stormwater management is a formula for stagnation and disaster.

Each community has a unique geology, climate, protection objectives and economic resources and objectives. Stormwater management programs need to be customized to meet local community needs not national uniform standards. EPA needs to ensure that it provides all technological options that can be used to meet unique regional and local needs.

8. Professional Consultants and Advisors

The consultant and advisors to EPA and other federal agencies that determine national policy have developed the same conservative approach to change and innovation as their clients. They give them what they want and expect, not necessarily what is needed. As an example, EPA has developed strong partnerships with very conservative national professional organizations such as the American Society of Civil Engineers (ASCE). There are many good reasons to work with national organizations like the ASCE but, if you are interested in promoting change and looking for innovation in ecological protection strategies, you won't find this group promoting radical changes. Instead, since conservative organizations are very much vested in traditional approaches, the direction they usually take is only refinement of their existing technologies and continued justification / rationalization of their basic approaches but, not paradigm shifts. What is needed is a far more diverse multidisciplinary group of advisors to federal policy makers to ensure a more comprehensive approach to advancing technology. All perspectives must be taken into account when developing policy and technologies.

9. Antiquated Analytical Tools

Current watershed analytical tools are inadequate to model the benefits of LID's source control approaches. Current tools were designed to model conventional approaches to stormwater management i.e. BMP's and detention. There are several efforts by EPA, Monash University in Australia and Prince George's County, Maryland to develop new hydrologic and water quality research modeling tools to verify the new technical approaches of LID. Furthermore there needs to be simple design tools to assist the site planner in understanding how to successfully apply LID to meet desired goals. Without tools to verify and for easy design LID techniques there will always be great resistance to change.

10. Lack of Resources for Research and Development and Education

Developing and adopting new approaches to doing business costs money. Resources are needed at every level for awareness education, training, research and development. There are numerous fragmented efforts for research, development and education among

many local, state and federal agencies. If for example, the federal agencies involved in outreach, assistance and research in urban stormwater management and related environmental fields of ecological protection were to coordinate and pool their resources to develop and promote LID technologies major advances could be made in a much shorter time frame.

11. Lack of Public Understanding and Support

Citizens and community organizations often do not understand the threats to water quality in their community, or the connections between urbanization and individual behaviors and water pollution. Much more effort is needed on educating the general public on their responsibilities to protect the environment through pollution prevention and to become active participants in the protection of water quality.

VI. What Steps Must be Taken to Implement LID

LID needs a jump-start to develop the necessary critical mass to overcome the inertia of instructional roadblocks. Once LID technology takes hold and is embraced and supported by government and professional institutions (becomes institutionalized and mainstreamed) it will develop rapidly on its own and will be self-sustaining and able to compete on its owns for resources due to LID's inherent economic and environmental benefits.

To develop the necessary critical mass, there must dedicated resources to implement a program for technological change. An example, of a program to promote a new approach is EPA's Smart Growth program that advocates growth management and more livable communities. A program of similar scope and magnitude for research, development and promotion of LID technologies would be adequate to ensure real change in a reasonable time frame. In general, a program to advance LID on a national level would include the following components:

- Provide for basic scientific research and development on LID modeling tools, practices, applications, monitoring and design standards.
- Develop general and technical guidance documents and materials on LID's benefits, principles, and applications. These guidance materials would be customize by regions (i.e., EPA regions) to address unique issues, goals and objectives.
- Develop targeted outreach and technical educational programs (seminars, conferences, workshops) for key institutions and professional advisors (local government, universities, home builders, civil engineers, planers, architects, etc.)
- Develop grant incentives for local and state government to demonstrate LID projects for both greenfields and urban retrofit.
- Require regulated municipalities through existing permit programs to include LID principle and practices to meet source water, stormwater and combined sewer overflow requirements.

- Require and provide funding for all Federal agencies and facilities to lead by example to use LID for all greenfields and retrofit projects.
- The Federal Highway Administration, EPA, Corps of Engineers, Department of interior and NOAA should develop joint cooperative programs to pool resources to advance and promote LID technologies.